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ACHIEVEMENTS IN THE FIELD OF ELECTRIC-SPARK METALWORKING IN THE USSR

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ACHIEVEMENTS IN THE FIELD OF ELECTRIC-SPARK METALWORKING IN THE USSR

/The following information is from the pamphlet Dostizheniya v Oblasti Elektroiskrovoy Obrabotki Metallov v SSSR, by B. R. Lazarenko, published by the Izdatel'stvo "Znaniya," Moscow, in 1952./

For several centuries the sole method of imparting to a piece of metal a required shape was machining, mainly by cutting, in which a given part of the metal was removed from the blank layer by layer with the aid of external forces.

The vigorous development of machine-building techniques has brought about ever-more exacting requirements for durability of mechanisms. Certain machine parts began to be manufactured of especially hard steel which was difficult to machine even with cutters equipped with hard-alloy blades. As a result, the machining of metals with cutters or abrasive materials became a bottleneck in the manufacture of machines.

In the past 10 years, a number of new technological processes which have greatly reduced the proportion of metal machining by cutting have come into use. These processes include forming, die stamping, drawing, and extrusion, as well as precision and centrifugal casting. A nearly finished blank is obtained from all these processes.

Until recently, the most economical method of performing such operations as tool grinding, grinding, and making special-profile parts was by cutting.

A radical change in the machining of metals began to take place after the discovery by Soviet scientists of the electric-spark method of processing. Metals of any physical and chemical properties can be machined by this method, and a number of technological processes which could not be performed by any other method are possible. In this method, no cutting tool is used.

At the end of the last century, for the first time in the history of techniques, metal-cutting machine tools began to be driven by electric power.

The path of electric power from the motor to the cutter is a matter of great interest. Over the past 70-80 years a great deal of work has been done to shorten this path as much as possible. In particular, the overwhelming majority of machine tools were converted from transmission-belt to individual electric drive. Thus, the electric power needed for the cutting process was brought directly into the machine tool. The tendency toward getting the power still closer to the machining zone led to shortening the transmission system in the machine tool itself and the conversion to multimotor drive of separate kinematic members of the machine tool, the control of these members being centralized. But the technological process of removing metal remained the same, i.e., the same mechanical forces removed the chip from the workpiece. It was obvious that it would be possible to bring the electric power even closer to the cutting point only if a process, based on a new principle, could be developed, through which the removal of metal from the blank would be accomplished by the direct action of the electric current.

Until recently, the electricity in machining of metals to specified dimensions played a secondary role, i.e., it drove the machine tool while the cutter machined the metal. Now, the electricity processes the metal directly, while the mechanisms play the secondary role of bringing the electrodes the tool and the workpiece together.

In the new process, mechanical forces are no longer needed. The electricity ceases to be the "source" of the force. It becomes the force itself.

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The complexity of solving the problem of rising electric power directly for removing the metal consisted of finding simple media which could be used to conduct the electric power to the exact spot on the blank where the machining was to take place. This problem has been solved in two ways: (1) by using electrochemical processes (electrolytic polishing and anode-mechanical machining), and (2) by employing the phenomena which accompany the instantaneous liberation of electric power, the electric-spark method of metalworking, or more precisely, the processing of metals by means of electric current impulses.

Electrochemical machining of metals to specified dimensions employs the phenomenon of the so-called polarization of electrodes, which sometimes attains such magnitude that the anode becomes "passive," i.e., there forms on the electrode a passive insulating film which cuts off the flow of current, and the anode ceases to dissolve in the electrolyte.

The process of forming this film of the polarized layer, as it develops at various stages, is shown in Figure 1, a [appended].

To prolong the electrochemcial process, the film which forms should be removed from the anode surface. There are three processing methods which differ one from the other by the means used to remove the film from the anode.

1. In the anode-mechanical method of metalworking (Figure 1, b), the film is stripped from the point where further processing is to take place by means of an electrically neutral scraper or brush.

2. In the electrochemical method of polishing metals (Figure 1, c), the film is removed by the forces of the electric field from the highest spots on the surface on the anode.

3. In anode corrosion of metals (Figure 1, d), the density of the current becomes so great that the film which is forming is unable to adhere to the surface of the anode and in the process of forming is continually torn away from the entire surface by the action of the electric field. As a result of this process, the anode surface cleans itself and the process of anode breakdown proceeds without interruption.

The anode-mechanical method of grinding metals has the following essential advantages over mechanical methods: (a) special abrasives become unnecessary; (b) the danger of searing the surface and the occurrence of deformation forces on the surface of the material being processed are eliminated.

The Ministry of Machine-Tool Building has put anode-mechanical machine tools for grinding tools and cutting metal into series production.

The electrochemical method of polishing (or more precisely, giving a gloss to) metals can take place only when the anode is not fully polarized, and the process of anodic corrosion has not set in. The composition of the electrolyte and the processing conditions (electrical, temperature, and time factors) must assure the breakdown of the polarized film only on the crests of the surface where to a large extent the lines of force of the electric field are concentrated. In the recesses of the anode surface, the film remains intact. Inasmuch as the crests which are removed have a total height of 2-3 dozen microns, it is evident that for each material appropriate processing conditions and electrolyte composition must be selected. Carbon and stainless steel, copper, lead, tin, bronze, nickel, zinc, aluminum, Monel metal, and others can be polished by the electrochemical method.

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The electrochemical method is particularly effective for polishing stainless steel. The surface polished by the electrochemical method possesses extremely high reflective properties (anodic fulguration); even at 2,500 magnifications, not the slightest scratch is visible on the polished surface.

Despite certain difficulties involved in the use of the electrochemical method of polishing metal items, it is in wide use and has effected great economies. It is particularly effective in polishing items which have surfaces which are hard to reach, such as springs, screens, engraving plates, etc.

The electrochemical methods of metalworking which have been discussed are based on the utilization of ionic processes which take place in electrolytes. Like all ionic processes, they are low-production processes and are used only for performing special operations.

Basic Information on the Essentials of Electric-Spark Metalworking

In 1938, at the All-Union Electrical Engineering Institute research was carried out which made it possible to assert that the only feasible universal method of electrical processing of metals is the use of the so-called electrical erosion of metals.

It was established that electrical processing of metals to specified dimensions can be effectively carried out only by means of a preliminary concentration of electric energy in time and space, and the subsequent instantaneous release of the stored energy in the section to be processed. This instantaneous and localized liberation of specific quantities of energy ejects the metal at the point where the impulse is applied, on which, naturally, the process depends.

Thus, we arrive at the idea for the basic electrical circuit for a unit operating on the electric-spark principle (see Figure 2 [appended]), this diagram being a series connection of a source of unipolar current impulses of 10^{-8} to 10^{-4} second duration and an interelectrode working gap.

It must be remembered that since the spark impulse is accompanied by an instantaneous drop in voltage on the electrodes, the duration of the described processes depends on the power of the voltage source which feeds a given circuit.

Two cases are possible. In the first of these, the power of the source is extremely low, or (which is the equivalent) the voltage on the electrodes is not maintained by a special supply source, e.g., the discharge of a charged capacitance. Then, if there are no inductive elements in the discharge circuit, the duration of the impulse is usually about 10^{-5} -10^{-7} second.

In the second case, where the impulse is of longer duration, for example, a voltage source adequate in power so that it can maintain the voltage on the electrodes for a certain time, the positive ions, over an interval of 10^{-4} second, falling on the cathode at the point where a through-conductivity channel begins, heat this point, and make it a permanent source of electrons. The process begins to stabilize itself -- it begins as an impulse discharge, and then becomes a stationary arc discharge.

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Equipment for Electric-Spark Metalworking

In keeping with the new electrical nature of the process of removing metal, the design of the "machine tool" which performs this operation is also changing. Since, in the electric-spark process, the removal of the metal takes place without the use of mechanical force, all the basic mechanisms which transmit the mechanical forces upon which the operation of a metalworking machine tool depends become unnecessary. The basic working member of an electric-spark processing unit is the source of impulses of the electric power, which by its operation brings about the appearance and development of the electrical processes, i.e., current impulses of less than 10^{-4} second duration.

The kinematic part of an electric spark unit is a secondary element; its function is to keep the necessary gap between the electrode tool and the electrode workpiece during the operation itself, and to provide the adjusting, and sometimes the working movements of the workpiece relative to the tool. At present, there has not yet been developed an electric-spark unit which embodies all the ideas of this method. The existing designs of such units still have a number of shortcomings and represent rather units of a transition period between mechanical metal cutting and electrical processing.

In the process of operating an electric-spark unit, the electrode tool must always be kept at some distance from the electrode workpiece, this distance being determined by the magnitude of the voltage on the electrodes and the composition and condition of the interelectrode medium. During operation, the sparks rend the metal from the blank under the electrode tool; as a result, the surface of the blank being worked steadily withdraws from the face of the electrode tool. After a certain time, the moment arrives when the space between the electrodes becomes such that the spark can no longer span it at a given voltage, and for this reason further progress of the process is interrupted. To continue the process, the electrodes must be brought closer together so that the spark may again be able to bridge the gap.

Hence, an electric-spark unit should be provided with a definite electromechanical system -- we call it the follow system -- which will maintain the optimum distance between the electrodes.

Going on to examine the design of follow systems for automatically maintaining the most suitable distance between the electrodes, it must be noted that since the units under consideration are electrical, it is evident that for fully automatic operation it is essential that the control of the movements of the follow system be organically integrated with the basic electrical circuit of the unit.

Of the many existing types of follow systems (such as hydraulic, solenoid, electrodynamic reversing motors, electromagnetic clutches, etc.) the best are the rigid follow systems, since they provide the most exact control and are less complicated to manufacture.

Over a comparatively short period of time, many different types of electric-spark unit designs have been developed.

The Leningrad engineers Ye. M. Levinson and Ye. I. Vladimirovich developed an electric-spark unit for performing precision operations (shown in Figure 5), i.e., for operations requiring high accuracy, particularly for making holes in dies and holes in hard-alloy drawing dies.

At a number of machine-building plants series production of similar units for making holes has been organized.

For 3 years now, the Leningrad Krasnogvardeyets Plant has been putting out spark units of original design for making dies.

The Leningrad Carburetor Plant is putting out electric-spark units for making holes in atomizer apparatus.

The best-designed unit for spark metalworking was developed and built by the Leningrad Forest Engineering Academy imeni S. M. Kirov (Figure 6).

This unit is designed for cutting blanks of any hardness up to 50 millimeters in diameter and 3 meters long. The electrode tool of this unit is an iron disk which is rotated by a one-kilowatt electric motor. The motor and the disk are mounted on a slide which travels vertically. A follow system automatically maintains the necessary gap between the disk and the work, which is fastened to a vise. The speed of disk movement is set by the follow system which is installed in the upper part of the unit. The tank is lowered by a special electric motor. The electrical part of the machine tool is located in the back part of the unit; the control switches are located on the side wall. The process of cutting metal with this electric-spark saw is fully automatic.

Electric-spark grinding of metals is a special group of electric-spark processes being used in industry with ever-increasing success.

Special units for electric-spark grinding are now being developed. The existing designs are modernized versions of grinding machines now in use. Practice has shown the expediency of using multicircuit layouts in given instances.

Electric-spark units for making chip breakers and chip winders have been successfully put into production. A number of enterprises have built such units themselves and have put them into operation. At the Moscow Krasnyy Proletariy Plant a unit for processing three cutting tools at once has been designed and built. It takes less than one minute to make the groove in a chip breaker on this unit.

The electric-spark method of metalworking greatly facilitates labor-consuming and heavy fitter's work. The Central Scientific-Research Laboratory for Electrical Processing of Materials has developed the first models of a fitter's tools on the electric-spark principle.

A great amount of work is being done by a number of institutes and plant laboratories on improving the different elements of electric-spark units. The Ministry of Electrical Industry has developed and is now putting out a block of condensers specially designed for use in electric-spark units, the new condensers calculated to meet the specific requirements placed on such condensers.

As is known, the majority of electric-spark units operate off direct current. On the other hand, not all enterprises have the costly and complicated equipment necessary to obtain direct current. A special mechanical rectifier which could feed various types of units would be of great help to the enterprises.

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Several variants of feed circuits have been developed which make possible a considerable broadening of the use of electric-spark processing.

Special circuits using vacuum-tube sources of the impulses have been successfully tested and are now beginning to be used in industry.

Technological Features of Electric-Spark Processing

The productivity of an electric-spark unit, i.e., the amount of electrode material ejected per unit time, is proportional to the product of the impulse energy by the circuit frequency.

The more impulses received by this or that section of the surface being processed, the greater will be its erosion. For example, in making a hole, the parts of the surface nearest the point where the electrode tool goes in will be subject to much longer erosion than the parts of the surface where the tool comes out.

There are many methods which make it possible to make a hole to an accuracy of a few microns. Particularly high precision can be obtained in making shallow holes.

From viewpoint of macro- and microgeometry the metal surface obtained by electric-spark metalworking is particularly interesting, if only because it is impossible to get such a surface with any mechanical means. Every single impulse removes a portion of metal from the anode, proportional to the impulse energy. After the removal of this portion of the metal there is a trace of a little hole left on the anode, this depression having an uneven, but nearly round shape. As a result of the subsequent reciprocal action of all points on the surface with the electrode tool, the processed surface is covered with tiny holes packed tightly together, but no longer having a definite shape.

The surface finish obtained by the electric-spark process does not depend on the type of electric-spark unit. In this respect electric-spark processing has a great advantage over mechanical. With the use of the electric-spark process one can obtain a surface with a fineness of finish up to and including the 10th Class.

For a more complete picture of the processes taking place on the surface of a piece of metal which is being acted on by current impulses, a few of the characteristics of the spark impulse are given below.

1. The temperature of the spark channel goes as high as 11,000 degrees (for comparison's sake, we may note that the temperature of the flame in an electric arc is about 3,500 degrees).

2. The stream of electrons, moving at great speed in the interelectrode gap to the anode, strikes its hard metal surface. As a result of this, the power of the electrons, which are suddenly stopped in their movement, is released on the surface layers of the anode.

3. The pressure exerted on the metal under the spark impulse reaches tens of thousands of atmospheres.

4. The spark impulse takes place with the simultaneous action of extremely powerful magnetic and electrical fields.

5. Since the time of the impulse effect does not exceed 10^{-4} second, the thermodynamic processes which take place on the surface of the metal are adiabatic processes.

The simultaneous action of all these factors brings about abrupt changes in the physical and chemical properties of the metal undergoing electric-spark treatment.

Figure 7 shows a microsection (200 magnification) of a piece of steel the surface of which has been impregnated with carbon by means of electric-spark processing. The illustration shows clearly the hardened layer of metal (the white layer) blending by degrees into the basic structure of the metal.

This white electric-spark layer possesses special physical and chemical properties, particularly increased hardness.

The surface obtained by electric-spark processing, now under consideration, when magnified even more (18,000 times) and compared with the initial structure of the metal, reveals that metal undergoing spark-impulse treatment sustains great deformation, leading to intensive refinement of its crystals.

Operations Performed by Electric-Spark Processing

Industry has begun wide-scale use of the electric-spark method for making holes in stopcocks, fuel and atomizer apparatus, and in wire-drawing, because this method greatly increases labor productivity.

For example, it takes only 35 seconds to make holes 0.152 millimeter in diameter to a tolerance of 8 microns in an injector nozzle.

Making various types of steel and hard-alloy dies by electric-spark processing permits great economies. Electric-spark processing of previously hardened blanks eliminates completely the reject of dies which frequently turn up in the heat treatment of steel dies made by mechanical means.

The spark process also makes it possible to decrease the size of webs in compound dies and in matrixes of subsequent dies.

Of all the working characteristics of dies, the most important index is the durability of the matrix. In processing metals by the electric-spark method, an improvement in the mechanical properties of the surface takes place, causing the matrix so made to have increased durability as compared with mono-type matrixes made by technical methods.

Since electric-spark processing permits working of metals of any hardness, it has become possible to make dies of hard alloys.

As already pointed out, the making of holes naturally resolves itself to one approach: the electrode tool passes through the thickness of the electrode blank, forming a hole of a given configuration. It is also possible, under other circumstances, to have the electrode tool only penetrate the surface layer of the blank without actually going through it. If the process is terminated when the electrode tool has penetrated 0.25 millimeter into the blank, the process is called electric-spark printing on metal. If the process is allowed to continue and is stopped when the electrode tool has gone 1-3 millimeters into the workpiece, we have the process of making embossing dies; if the process is allowed to go on still further, we will be making forging dies, pressmolds, chill molds, etc.

Hence, the electric-spark method makes it possible to get extremely accurate copies of the electrode tool in the thickness of the electrode blank. This feature derives from that property of the electric-spark discharge which only allows the discharge to take place between those points of the electrodes which are closest to each other.

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For instance, one point of the cathode need be only 0.01 millimeter closer than any other points to the surface of the anode to have a spark electric discharge take place just at that point, i.e., the depression where the metal was torn out will be left in exactly that spot on the anode.

Consequently, if the working surface of the electrode tool is a convex negative impression of a given shape, it is possible to transfer this impression to the workpiece. Working practice along this line has shown that with electric-spark processing, it is possible to make imprints of the greatest variety of complexity on the surface of materials of any hardness, from printing of texts to making highly artistic engravings on tempered steel.

Particularly interesting are electric-spark processes for making pressmolds of embossing and forging dies.

Figure 8 shows a pressmold for making plastic dishes. The engraving work was done by the electric-spark method.

This new method also makes possible the manufacture of bimetal dies. A die of this type consists of a steel base (U-8 steel) and a layer of Sormite hard alloy. The entire machining of this die is done by the electric-spark method. The durability of such dies is extremely great.

Figure 9 shows a bimetal forging die for making razors, and forgings made with the die.

One feature of this method of making dies is the possibility of repeated restoration. The worn die is not thrown away; its surface is ground down a bit and the depressions restored by means of the electrode tool with which it was made in the first place. This makes possible very efficient use of die metal. It is now evident that in the near future Soviet forging will convert to the use of hard-alloy tools, which will save a great quantity of high-alloy steels and increase the productivity of the shops.

The use of the electric-spark method for grinding metals, which is performed without the slightest pressure on the tool or the blank, is highly expedient. In this method of grinding the need for abrasive materials is eliminated. The electrode tool is made of ordinary gray iron.

Stepless grinding is performed very easily by the electric-spark method. It is done with one and the same disk, with one setup of the work. Only the parameters of the electric circuit are changed. Since the particles of metal which are being removed are normally dispelled on the surface, the disk continues to work smoothly, and after the grinding it is easy to detect all surface defects (microcracks, for example).

The same disk can grind metals of any hardness, including extremely tough metals. Electric-spark grinding is now finding extremely varied application, from grinding magnetic alloys, hard alloys, and porous chrome to removing burrs after welding and grinding railroad-car wheel tires. Electric-spark grinding of iron blocks used in the manufacture of machines and instruments makes possible a reduction of magnetic losses in them. Electric-spark tool grinding and finishing of hard-alloy tools, a process related to electric-spark grinding, vastly exceeds in productivity all previously known methods of grinding tools. The same can be said for the electric-spark cutting of metal.

If special electric-spark units for grinding hard-alloy tools are not available, it is a simple matter to convert existing types of tool-grinding machines into electric-spark units for this sort of work by means of a few simple modifications. The most appropriate designs for this purpose are machine tools equipped with a tank, pump system, and an oscillating spindle.

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It has just become possible to manufacture and grind form cutters plated with hard alloys by the electric-spark method. For one of the kinematic systems for performing this process the following can be recommended: In the chuck of a lathe, electrically insulated from the body of the lathe, a cast-iron disk is fastened. The necessary profile is imparted to the disk by a cutter. Next, the hard-alloy-plated tool which is to be profiled is fastened to the tool slide of the machine tool. The disk and the hard-alloy-plated cutter form the electrodes of the discharge circuit. Thanks to the electric-spark method of machining, the hard-alloy cutter soon has the profile originally imparted to the disk.

It is generally known what effect chip breakers and chip winders have on the front edge of a cutting tool. However, they are frequently not put on hard-alloy tools because of the difficulty of making them. Practice in Soviet plants has shown that high-quality chip breakers and winders can easily be made even on hard-alloy tools by means of electric-spark processing.

Since in grinding tools by the electric-spark method a comparatively small amount of metal is removed, it is possible to use alternating current if special direct-current sources are not available. In using alternating current it is only necessary to take into consideration the fact that alternating current lowers the productivity of the process and increases the wear of the cast-iron disk.

Electric-spark cutting of metals is a high-production process, being used more and more by industry. By means of this process it is possible to cut very fine parts with great precision (parts of less than one cubic millimeter in size), as well as blanks up to 800 millimeters in diameter.

Electric-spark band saws are now beginning to find application in industry.

In the electric-spark cutting of metals a fine slit only about one millimeter wide is formed. This effects a great saving of metal.

The speed of cutting metals with an electric-spark saw is extremely high. For example, to cut a steel blank made of manganous steel measuring 50 by 170 millimeters takes only 3 minutes; railroad rails, 2 minutes; stainless steel blanks 25 by 58 millimeters, 35 seconds; and RF-1 steel blanks 10 by 70 millimeters, 20 seconds.

The liquid medium ordinarily used in electric-spark cutting of metals is water to which a small quantity of clay has been added.

Electric-spark processing has won a secure place in repairing machine parts and in performing repair and renovation work. We know, for example, that the processes of drilling and particularly thread cutting in holes are operations which are usually performed at the end of the machining cycle. For this reason, it is extremely unpleasant when during these operations the tool breaks and the stump of the drill or tap remains in the hole. In most cases the nearly completed part goes into the scrap heap. Using the electric-spark process, it is an easy matter to eliminate the scrapping of parts due to this cause. It is only necessary to drill a hole through the drill or tap, after which the remains of these tools may be removed from the hole without difficulty. Figure 10 shows a tap and a drill broken down by the electric-spark method.

In repair operations it is often difficult to extract bits of broken pins, bolts, etc., from holes. By the electric-spark method this operation can be handled without difficulty. To extract a broken piece, a square electrode tool is used; this tool sinks into the pin or bolt, which is then removed by means of a square socket wrench. Electric-spark units specially put out for this purpose make it possible to perform these operations very quickly and simply.

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Dozens of instances may be cited in which electric-spark processing has greatly facilitated a repair job. Particularly interesting is the case of restoring the original dimension of shaft journals which have lost their shape from constant bearing pressure. There are great possibililites of using the electric-spark method for restoring and using worn-out tools as blanks. For example, segments for a circular saw can easily be made from old disk mills by this method (Figure 11).

In restoring broken tools the jagged edges of the break in the drill, cutter, broach, or other tool are ground down. This long operation leads to heating of the tool and entails a nonproductive expense of abrasives and time. With a small bench device -- a small electric-spark saw -- this operation can literally be done in a few seconds, and the toolmaker need only give the proper geometry to the cutting edge.

The impulse liberation of electric energy makes possible, among other processes the electric-spark hardening of metal surfaces by depositing a layer of more wear-resistant material on the processed surface or by introducing into the surface layers of the processed item various alloying elements.

Figure 12 shows a microsection of a steel part on the surface of which a layer of T15K6 hard alloy has been deposited. As is shown in the illustration, deep diffusion of the hard-alloy layer into the steel surface has taken place in this instance. It is this deep diffusion which explains the exceptional toughness of the fusion of the alloy layer deposited by the electric-spark method and the metal which is being reinforced.

The so-called contact variant of this method is done with a vibrating or rotating attachment, the purpose of which is the periodic change of the interelectrode space to that magnitude at which electric spark-over will occur, i.e., the instantaneous release of the energy stored up in the system.

This method of depositing metal coatings has three extremely important advantages over the methods being used at present:

1. Extreme toughness of the fusion between the layer deposited and the base metal.

2. The possibility of plating both pure and alloyed metals.

3. The absence of any need for preliminary preparation of the surface on which the layer of wear-resistant material is to be deposited.

Electric-spark hardening of metal surfaces is used in a great many fields of industry, mainly for hardening cutting tools, dies, parts for agricultural machines. etc. The work being done in this field is making it possible to sharply increase the productivity of labor, to cut production costs, and to save a great amount of metal and power.

Electric-spark hardening of cutters, drills, milling cutters, broaches, countersinks, circular saws, dies for cold and hot working, pneumatic punches and slice bars of cushioning hammers, woodworking tools, cutting members of agricultural machines, etc., with hard alloys is being widely used in industry.

Hard-alloy hardened tools and dies possess more durability than ordinary tools. The spark hardening of such tools as punches, and slice bars of cushioning hammers increases their length of service 15-20 times.

Cultivator plowshares reinforced with hard alloy possess a durability 2.5 times greater than nonreinforced shares. Moreover, they are self-grinding as they work, an extremely valuable feature in a tool of this kind.

At present, rolls for rolling mills are beginning to be hardened by the electric-spark method by covering them with hard alloy.

The quick mastering of this method is largely responsible for the Leningrad Kinap Plant's producing a series of special electric-spark units.

The most modern type of unit for electric-spark hardening has recently been built at the Central Scientific-Research Laboratory of Electrical Processing of Materials under the Ministry of Electrical Industry USSR.

In designing this unit, maximum dependability and high productivity were given main attention. These were achieved by three means: (1) selection of such electrical parameters for the circuit that the operator is under no circumstances able to violate a given optimum setting for a job; (2) great simplicity of controlling the unit aimed at maximum reduction of the operator's movements and of auxiliary time; (3) introduction of a special automatic device which feeds the working voltage to the electrode and cuts in the vibrator only after contact of the electrode tool with the work; it automatically shuts off the vibrator in 0.5 second and drops the voltage off the electrodes when the hardening process is stopped. All these features permit great simplification in the control of the entire unit. The control is effected through a single lever. The machine can be attended by a worker having no special skill.

Figure 13 shows a hob being hardened on a UPR-3 unit by the electric-spark method.

At many Soviet enterprises the process of hardening and restoring dimensions to complex tools is being mastered. Among such tools are hobs, large punching dies, reamers, etc.

The use of electric-spark hardening of tools cuts down on the consumption of tool steel and electric power since frequent resharpening of a tool is not necessary; it raises labor productivity and lowers the cost of production.

Electric-spark hardening is beginning to be widely used in restoring dimensions of-worn-out tools. Worn-out reamers, files, and other tools are now being restored by this method. A great deal of serious attention is being given to the use of the electric-spark method for hardening machine parts. At first, only lathe centers and various cams were hardened by this method and dimensions restored to seating surfaces; ways of various machine tools, bushings and spindles for high-speed machine tools and devices can also be hardened by the electric-spark method. Practice is showing that this process not only sharply increases the wear-resistance of the part processed, but actually makes possible the replacement of nonferrous metal with ferrous in a number of cases.

This method of hardening machine parts for the purpose of increasing their life and length of service is being used ever more widely.

The development of electric-spark metalworking is moving in two directions. One of these, making cutting tools harder, supports the ordinary cutting method of machining metal and makes the position of this method more secure; the other, the basic direction of electric-spark processing, is to compete successfully with mechanical methods and in substance negate the value of ordinary metal cutting as a primitive, imperfect method.

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All theoretical research and actual practice are indicating that all technological processes and operations performed by mechanical cutting can be performed by the electric-spark method. The new problem of machining metal faster, cleaner, and with greater precision than can be attained by mechanical methods has been posed, and is now on its way to successful solution. There is no doubt that every year more processes now performed by mechanical cutting will be switched over to the simpler and cheaper electric-spark "cutting" process.

It is certain that the new possibilities in the production and processing of parts and the availability of harder materials for them will influence the design of contemporary transport, agricultural, textile, construction, and other machines, instruments, and apparatus. They will become lighter, stronger, and more durable.

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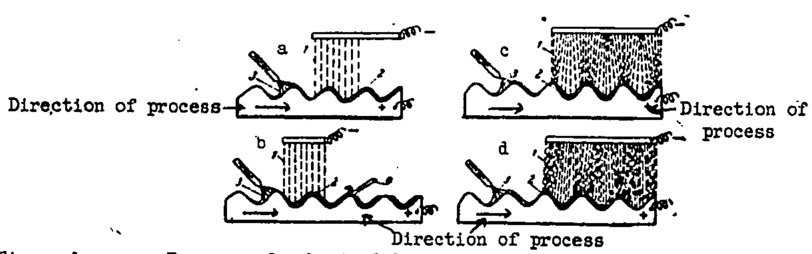
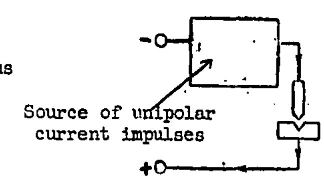


Figure 1. a -- Process of polarized layer formation; b -- Diagram of the anode-mechanical metal-working process; c -- Diagram of the electrochemical metal-polishing process; d -- Diagram of the process of anode corrosion of metals.

1 -- Electric field; 2 -- Polarized film; 3 -- Electrolyte; 4 -- Electrically neutral scraper.

Figure 2. Basic Circuit of an Electric-Spark Apparatus



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